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Early Warning and Crop Condition Assessment

July 1981

AGRICULTURAL RESEARCH SERVICE RESEARCH HIGHLIGHTS IN REMOTE SENSING FOR CALENDAR YEAR 1980

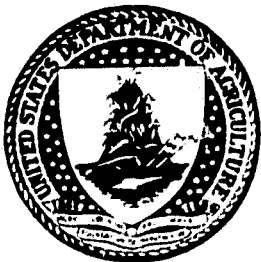
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IN
REMOTE SENSING FOR CALENDAR YEAR 1980

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16. Abstract <p>This report is a compilation of highlights of research accomplishments related to remote sensing by Agricultural Research Service (ARS) scientists during calendar year 1980. A list of 1980 publication and location contacts is given also. More details on specific research projects and copies of publications can be obtained from the specific location contact.</p> <p>This report was abstracted from the annual research progress reports prepared by ARS research scientists and is part of the ARS Annual Report on Soil, Water, and Air Research Accomplishments. Copies of the Annual Report of the Soil, Water, and Air Sciences Research can be obtained from Jerry C. Ritchie.</p>					
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Agricultural Research Service Research Highlights

in

Remote Sensing for Calendar Year 1980

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This report is a compilation of highlights of research accomplishments related to remote sensing by Agricultural Research Service (ARS) scientists during calendar year 1980. A brief statement is given to highlight the significant results of research projects. A list of 1980 publication and location contacts is given also. More details on specific research projects and copies of publications can be obtained from the specific location contact.

This report was abstracted from the annual research progress reports prepared by ARS research scientists and is part of the ARS Annual Report on Soil, Water, and Air Research Accomplishments. Copies of the Annual Report of the Soil, Water, and Air Sciences Research can be obtained from Jerry C. Ritchie.

I would like to acknowledge the input of each ARS scientist whose research contributed to this report, the editorial assistance of Margaret Hunanian, and the assistance of Sara Jean Binder and Julia Scaggs in the preparation of the copies of the text.

Special Research Program

REMOTE SENSING

Remote sensing, or aerospace technology, is a technology (tool) that has the potential to provide data for many action agency programs and AR research programs. The AR research mission in remote sensing is to develop the basic understanding of the soil-plant-animal-atmosphere continuum in agricultural ecosystems and to determine when remotely sensed data can be used to provide information about these agricultural ecosystems. Once these systems are understood, systems and models can be developed that can use remotely sensed data efficiently and effectively. Remote sensing research is carried out under four general technological objectives as follows:

Technological Objectives

1. Secure a better understanding of the emission and reflectance properties of biological and physical parameters through spectrophotometric analyses in the laboratory, in the field, and from low altitudes and space.
2. Develop procedures for utilizing remote sensing techniques for identifying crops and for measuring their acreage, stage of growth, and health as affected by disease, insects, nematodes, other pests, weeds, and by other environmental factors such as nutrition, salinity, soil moisture, erosion, temperature, and pollution.
3. Develop remote sensing methods to improve water and soil management, soil erosion control (wind and water), sedimentation control, soil mapping, watershed planning, water supply and runoff forecasting, and establishing land capability.
4. Continue efforts to investigate, develop, and utilize information obtained from the unique characteristics of space-acquired remote sensing data which are not available by ground and aerial means, and continue to develop the use of that data to improve the speed, coverage, and accuracy of surveys now done by conventional ground and aircraft techniques.

Research under these technological objectives is funded and performed under the appropriate National Research Program (NRP). The following locations and NRP's contribute to the remote sensing program.

SRP Contact: J. C. Ritchie

Research Locations and NPR's:

Weslaco, Texas	20220	Sidney, Montana	20760
Tifton, GA	20240	Mandan, North Dakota	20760
Weslaco, Texas	20270	Pendleton, Oregon	20760
Gainesville, Florida	20740	Houston, Texas	20760
Bushland, Texas	20740	Temple, Texas	20760
Phoenix, Arizona	20760	Weslaco, Texas	20760
Akron, Colorado	20760	Raleigh, North Carolina	20790
Fort Collins, Colorado	20760	Oxford, Mississippi	20800
Gainesville, Florida	20760	Pullman, Washington	20800
Urbana, Illinois	20760	Tifton, Georgia	20810
Ames, Iowa	20760	Boise, Idaho	20810
Beltsville, Maryland	20760	Beltsville, Maryland	20810
Mississippi State, Mississippi	20760	Temple, Texas	20810

Examples of Recent Progress:

Lethal yellow in palms detected with aerial photography - Weslaco, Texas (20220)
An aerial photographic survey technique was developed to differentiate healthy, diseased, and dead palm trees in the Lower Rio Grande Valley. This survey technique will be beneficial to the management of palms and to scientific studies initiated in the Lower Rio Grande Valley to develop methods of control or eradication of lethal yellowing disease of palms.

More accurate navigational method developed for aerial photography - Weslaco, Texas (20220). A navigational method using existing airplane navigation equipment for standard enroute flights was developed for aerial photo missions. This method eliminates the use of ground references but results in flight lines that are on course; and the center of each photographic frame is located at equal distance from the center of each adjacent frame. This more accurate frame location will allow repeated coverage identical to that from previous flights.

Infestations of rice borers in sugarcane identified with color infrared aerial photography - Weslaco, Texas (20220). Using color infrared aerial photography, rice borer infestation can be monitored to aid in control or eradication procedures. Infestations of rice borers were visible on photographs with a scale of up to 1:20000. Sugarcane varieties more susceptible to rice borer damage could be delineated from those showing resistance.

Radar used to identify insect movement - Tifton, Georgia (20240). A program using radar to identify insect flight in southeastern U.S. began in August 1980. This tool provides new information about an important stage of an insect's life cycle and will be used for planning pest control strategies.

Color infrared photography used to identify fungus in spinach - Weslaco, Texas (20270). In replicated plots of spinach cultivars with different levels of resistance to the white rust fungus, serial infrared color photography at 330 and 660 m could be used to identify three infection levels; 21, 7, and 5 percent infected leaf areas. Only the 21 percent level could be identified by conventional color photography.

Thermal infrared scanner used to determine regional evapotranspiration (ET) - Gainesville, Florida (20740). Using ground-based ET measurements, a surface-to-air transport coefficient for heat transport was determined from short grass. From a map of surface temperatures, an ET map was constructed, and ET from a 3.8 km² and a 13.5 km² area was computed. The ET values were computed as the difference between net radiation and soil heat flux plus sensible heat flux. ET values can easily be obtained regionally if surface-to-air transport coefficients are known, and surface-to-air temperature differences are known. The surface-to-air transport coefficients are much higher for short grass than for tall vegetation.

Winter wheat growth measured in Southern Plains - Bushland, Texas (20740). Full season climatic data sets were obtained on fields in the two important wheat growing regions of the Southern Plains—at Vernon, TX, in the Rolling Red Plains, and at Bushland, TX, in the Southern High Plains. Climatic data included hourly measurements of windspeed, air temperatures, humidity, incoming and reflected radiation, and rainfall. Additional data collected were soil water, available soil nutrients, plant development, height, wet and dry weight

of vegetation, leaf area index, grain yields and yield components, and spectral reflectance using a Mark II 3-band radiometer. Spectral data are being analyzed for relationships with plant porometer measurements. These data sets are used to validate wheat yield models being developed by other AR scientists.

Plant growth parameters related to spectral properties - Bushland, Texas (20740). Preliminary data were obtained from studies with winter wheat, corn, grain sorghum, and sunflower. Results indicate significant relationships between spectral vegetative indexes and green leaf area, biomass, dry matter accumulation, and the potential feasibility of using remote sensing to assess water deficit effects on field crops.

Dew affects spectral characteristics of wheat - Phoenix, Arizona (20760). Dew-covered wheat canopies have different spectral characteristics than does dry vegetation. Spectral measurements were made concurrently over field plots where dew occurred naturally and where it was excluded artificially. The results demonstrate that dew may complicate the interpretation of crop characteristics if data from a satellite with an early morning overpass time are used. Dew measurement by remote, nondestructive spectral techniques has a potential role in the prediction of dew-related plant diseases.

Crop water stress index developed - Phoenix, Arizona (20760). A crop water stress index, based on foliage temperature measurements, was developed from two independent approaches, one theoretical and one empirical. Necessary inputs are foliage temperatures, air temperature, vapor pressure deficit, and for the theoretical approach, an estimate of net radiation. By incorporating atmospheric factors, the index should be applicable in different environments. An immediate application of the index is as a tool in irrigation scheduling.

Sun angle affects spectral measurements - Phoenix, Arizona (20760). Research with hand-held radiometers demonstrated that sun azimuth and altitude angles dramatically affect spectral vegetation indices used to infer crop characteristics. Results show that satellite data can be influenced by row orientation and sun angle effects that are not included in current "sun angle" corrections, which merely account for changes in illumination intensity due to sun elevation. Further, the results demonstrated that detection of low green biomass levels is enhanced by low sun angles, while discrimination of high green biomass levels is best accomplished under high sun angles.

Data collected on winter wheat growth in Central Great Plains - Akron, Colorado (20760). Morphological development of winter wheat and water use data were collected from five sites in the Central Great Plains during the 1979-80 crop growth period. Average combine yield for the five locations was 23.9 quintals/ha, while calculated yield was 25.7 quintals/ha. The difference between the two measures of yield was 1.8 quintals/ha which is three times the difference in previous years. The maturation period in 1980 was hot, windy, and dry which caused considerable shriveling of the kernels. Calculated yields included all kernels, but many of the shriveled kernels were lost during harvest. These data are being used to validate wheat yield models.

Wind reduces winter wheat yield - Akron, Colorado (20760). During the grain filling growth stage of winter wheat, a portable wind tunnel was used to expose wheat to wind of 38 km/hr for durations of 2, 4, and 8 hours. Tests were made on well-watered wheat and wheat that had been grown under water stress. With

well-watered wheat, the 2-hour test decreased the grain yield 4.0 quintals/ha/hr; the 4- and 8-hour tests decreased the grain yield 1.7 and 1.8 quintals/ha/hr of test, respectively. Decreases in heads/m², kernels/head, and weight/kernel were of the same magnitude and in the same order as the grain yield decreases. With wheat grown under water stress, the 4-hour test decreased the grain yield 2.4 quintals/ha/hr of test; the 2- and 8-hour tests decreased grain yield 1.9 and 1.1 quintals/ha/hr of test. Yield component decreases followed the same pattern. Thus, with stressed wheat, it took a longer time to decrease the grain yield and the decreases were, in general, one half those that occurred in the well-watered wheat.

Winter wheat climatic data processed - Fort Collins, Colorado (20760). Plant growth, climate, and soil data for winter wheat were gathered in the Great Plains. These data have been processed for testing and development of wheat yield algorithms. Data from nearby weather stations were obtained and computer programs developed for estimating missing data in the climatic files. Estimation procedures have been completed for the seven sites being operated from Fort Collins and Akron for the years 1977-78 and 1978-79. Progress is well along in estimating the missing values for the 1979-80 wheat growing season.

Conceptual model of snowpack properties developed - Fort Collins, Colorado (20760). A conceptual model of snowpack accretion and of snowmelting has been developed. This model is intended for use in the soil water balance component of the wheat yield models.

New theory and data on water and CO₂ transfer - Urbana, Illinois (20760). Theory and data have been developed which permit prediction of photosynthesis and plant transpiration from parameters measured with aerospace technology. The input information are air temperature, leaf temperature, net radiation, thermal radiation, and boundary layer thickness.

Soybean physiological model completed - Urbana, Illinois (20760). SEA-AR and University of Florida scientists collaborated in developing soybean submodels for predicting the date of flowering and the photosynthesis for nitrogen fixation. This collaboration led to a soybean physiological model which is now in the testing stage. Further developments in subroutine models are planned.

Root water uptake model validated - Ames, Iowa (20760). Data collected in 1979 in a comprehensive field experiment to help validate the root water uptake portion of the soybean growth model were collated and published. Radiation absorption and dry weight accumulation late in the growing season controlled soybean yields. Rain late in the growing season negated possible seed yield differences due to the irrigation treatments.

Spectral measurements related to wheat yield - Beltsville, Maryland (20760). Significant relationships were found between yield (forage yield in alfalfa, total dry matter accumulation in wheat, and wheat grain yield) and remotely sensed spectra. One year's wheat yield data, from ground-based experiments, showed that about 60 percent of the variation in yield could be associated with spectral measurements in wavelengths corresponding to Landsat-D's thematic mapper bands 3 and 4.

Physiological wheat model verified - Mississippi State, Mississippi (20760). The "WHEAT" simulation model was coded in FORTRAN, verified, and run with a

a validation data set from Akron, CO. The test indicated that controlled environment experiments are needed to provide better estimates of rate equation coefficients for certain physiological processes in wheat.

Physiological soybean model verified - Mississippi State, Mississippi (20760). Coding of all subroutines has been completed. Some modification of the RHIZOS subroutines was necessary because of the interaction between root and shoot growth in the soybean model. This modification has been made and the RHIZOS subroutines interfaced to the rest of the model. Initial choices have been made for all parameter values based on available data; none remain to be estimated during validation. Verification of individual subroutines is nearing completion.

Physiological cotton model validated - Mississippi State, Mississippi (20760). Validation of the cotton simulation model (GOSSYM) has been extended to include two crops from Tucson, AZ, two crops from the Mississippi Delta, and 51 crops from five different climatic regions of Israel. Given the insect population levels, GOSSYM is capable of simulating lygus damage in cotton, and analyses with the model indicate that lygus commonly delays peak flowering by up to 2 weeks and reduces yield by 25 to 40 percent with current pest management practices in the Mississippi Delta. GOSSYM can be used to do much of the current testing of shallow and deep tillage practices in relatively costly field plot experiments. GOSSYM is providing a useful synthesis of plant physiological and soil information in breeding efforts underway at this location and in collaboration with cotton breeders in New Mexico and Israel. Experimental work to extend this model to the simulation of severe drought in cotton has shown that photosynthetic efficiency declines continuously during a drying cycle with no evidence of accommodation by the crop canopy. This appears to be partly due to the cessation of new leaf initiation and the senescence of the crop canopy as the drought progresses.

Data collected for wheat canopy interception model - Mississippi State, Mississippi (20760). Canopy light interception was measured continuously during the entire developmental period in the wheat crops in the five SPAR units. Leaf area and plant height were recorded in each of the chambers on a weekly basis. Enough data were obtained for the development of a model of a wheat canopy's light interception.

Water use and energy balance of wheat measured - Sidney, Montana (20760). A recrop experiment compared water use and energy balance of winter wheat seeded on summer fallow to those of chemical stubble fallow without a crop. About 9 cm of rain fell during the cropping season. The fallow lysimeter lost 2.5 cm water; the cropped lysimeter, 14 cm. On a representative clear day in June 1980, net radiation was 333 ly/day over wheat and 308 ly/day over fallow. Of that energy 294 and 134 ly/day was contributed to latent heat of evaporation over wheat and fallow, respectively, and 170 ly/day, to downwind advection.

Range model tested - Sidney, Montana (20760). A climate, water-balance range model was tested on several ecosystems and resource management problems. The model is currently being evaluated with data from the Reynolds Creek Experimental Watershed, which represents a wide range of vegetation types and climate. Work has continued with the Bureau of Land Management (BLM) in Montana to use the model for determining yield potential of BLM-inventoried range sites.

Data collected for wheat model validation - Mandan, North Dakota (20760). After 2 years of study at nine field locations, grain yields ranged from 940 to 3,760 kg/ha based on 156 and 48 individual yield observations of hard red spring wheat (HRS) and Durum wheat, respectively. For HRS, the number of heads/unit area accounted for 64 percent of HRS grain yield variability, kernels/head accounted for 12 percent, and kernel weight for 16 percent. For Durum, in contrast, the number of heads/unit area accounted for 46 percent of the Durum yield variability, kernels/head for 19 percent, and kernel weight for 34 percent.

Leaf area index (LAI) is useful in predicting spring wheat yields - Mandan, North Dakota (20760). The ability to predict spring wheat yields depends upon our understanding of how yield indices, components of grain yield, and the grain filling processes are influenced by soil-plant environment interactions with cultivars. The LAI of field-sown hard red spring wheats (HRS) has not exceeded 4, the maximum occurring after full expansion of the flag leaf. It varies with water supply. Leaf development rate of 12 HRS cultivars averaged 5.3 days per leaf from seedling emergence through expansion of the flag leaf.

Grain accumulation rates in hard red spring (HRS) wheat measured - Mandan, North Dakota (20760). Grain dry matter accumulation rate in HRS and durum cultivars over two seasons was a cubic function of either days or cumulative photothermal units (PTU's) after anthesis. Accumulation rate during the linear development phase averaged 1.1 mg/kernel/day in 12 HRS cultivars in 1979; or it required about 375 PTU's to accumulate 1 mg dry matter/kernel. Maximum nitrogen (N) concentration in grain occurred 4 to 7 days after anthesis, then decreased to a minimum about midway through linear phase of dry matter accumulation. The N uptake rate during the linear phase averaged 0.028 mg/kernel/day.

Winter wheat tillering sensitive to temperature and nitrogen (N) supply even in winter - Pendleton, Oregon (20760). The yield component most closely correlated with wheat yield in the Pacific Northwest is heads/unit area. Tiller occurrence, utilizing a linear relationship with the accumulation of degree days after emergence was successfully predicted at separate field sites. Low N supply is a major trigger for tiller abortion. Low N supply also stops tiller production but tillering can be restarted by adding N fertilizer. Specific levels of N that trigger these tillering changes are within the range normally found in commercial production fields. Thus, managing timing and amounts of N fertilizer can be a tool for controlling plant tillering and tiller survival.

Data collected for wheat model validation - Pendleton, Oregon (20760). Three field sites used for water conservation studies (one each in a 200-, 300-, and 400-mm precipitation zone) were selected in the fall of 1979 for evaluation of meteorological, soil water, and fertility effects on phenological development and yields of winter wheat. Meteorological stations were placed on the field sites to sense incoming and reflected solar radiation; net radiation; ambient, daily maximum, and daily minimum air temperature; wind travel; precipitation, and soil temperature at 0.5 and 5.5 cm.

Corn stress model developed - Houston, Texas (20760). A phenologically based moisture- and temperature-stress indicator model for maize was developed and tested for domestic and foreign synoptic performance. A literature search, personal contacts, and evaluation of existing models contributed to parameter definition and model construction. This model is used as a means to identify areas of the globe where maize is under thermal and water stress.

NOAA satellite spectral data used in place of Landsat images - Houston, Texas (20760). Computer software was developed to use NOAA-6 satellite images for grid overlays and to extract the AVHRR data for vegetative indices. Information content of the NOAA-6 data correlated well with Landsat data. The software was transferred to Foreign Agricultural Service (FAS) and modified for faster throughput by NASA and FAS, which provides a capability to analyze improved temporal data sets to complement the Landsat system. Additional procedures have been developed to evaluate differences between NOAA-6 and Landsat resolution.

Operational test to use GOES to estimate solar radiation successful - Temple, Texas (20760). An operational system test for estimating solar radiation from geostationary satellite (GOES) information was conducted during the summer of 1980. Satellite estimates and ground measurements were compared at five locations. At Temple, 95 percent of 60 satellite estimates were within ± 45 langleys per day of the measurements. The operational system makes daily estimates on a half degree latitude and longitude matrix. Individual location estimates are interpolated from the matrix. A new simplified computer routine for converting GOES data into daily solar radiation estimates was developed at Temple.

Soil nitrogen (N) simulation models developed - Temple, Texas (20760). Sub-routines for simulation of soil N immobilization and mineralization were written for addition to an existing crop growth simulation model. The immobilization subroutine is sensitive to residue composition, temperature, and soil water. The mineralization subroutine includes equations to estimate potentially mineralizable N from soil properties.

Ecological wheat model improved - Temple, Texas (20760). The ecological wheat model has been tested in cooperation with the Economic & Statistics Service. The test showed weakness in the vegetative and rooting depth function. Reevaluation of the functions involving morphology and growth of vegetative organs is underway. Research is also underway to better model vernalization. The model is being tested and used in several countries and gives good results.

Effect of atmosphere on reflectance measurements explained - Weslaco, Texas (20760). A simplified linear formulation of atmospheric radiative transfer has been developed to convert Landsat digital count data to ground reflectance for optically thin atmospheres. This formulation will permit more efficient expression of hand-held and field spectroradiometer data in terms of Landsat (top of atmosphere) digital counts and of Landsat data in terms of ground and aerial measurements.

Regional aridity indexes determined by satellite - Weslaco, Texas (20760). The relative degree of vegetative stress has been determined by comparing early afternoon surface temperatures indicated by the Heat Capacity Mapping Mission satellite with maximum air temperature for the day recorded at 13 weather stations. This difference of temperature at a weather station locale is defined as the aridity index. In the environment of southern Texas the aridity indexes on summer days generally increased with distance inland from the Gulf of Mexico, corresponding with the change from coastal prairie to irrigated cropland, to interior rangeland, and with a natural decline of rainfall with distance inland. The magnitudes of the aridity indexes increased from the end of May to July in response to the seasonal increase in evaporative demand and decreasing available soil moisture in the rangeland. Immediately after region-wide rainfall in early

June, the aridity indexes at all locations approached zero. These findings warrant further tests of the validity of this method for estimating vegetative stress on a synoptic scale.

Crop field temperatures observed by satellite shown to be strongly affected by water availability for evapotranspiration - Weslaco, Texas (20760). The temperature of sorghum, citrus, and sugarcane fields was related to three different measures of water availability: amount depleted since the last rain or irrigation; number of days since rainfall or irrigation; and ratio of actual evapotranspiration to potential evapotranspiration on the day of the satellite temperature observation. This research is one of the first demonstrations of quantitative evapotranspiration measurements versus satellite-observed surface temperature, and implies that the thermal data will complement other methods of identifying and monitoring droughts and their effects on productivity of crop and rangeland during the growing season.

Winter wheat heading controlled by daylengths - Weslaco, Texas (20760). Winter wheat production at latitudes below about 30°N is due to insufficient cold for vernalization, but growth of winter wheat for two seasons at 26°N latitude demonstrated that ample chilling was received for vernalization. However, the plants of important Great Plains winter wheat cultivars would not change from vegetative to reproductive growth until about March 1 when days became 12 hours long. Consequently, heading was delayed until about April 20. By then, air temperature was high, the plants senesced rapidly, and shriveled kernels were produced. These results suggest that incorporating genes that reduce the photosensitivity by about 45 minutes could extend the winter wheat belt as much as 300 kilometers to the south.

Early detection of freeze damage - Weslaco, Texas (20760). Several studies indicated that spectrophotometric leaf reflectance measurements at the 1.65 μ m wavelength detected freeze damage to leaves much earlier and just as accurately as the electrolyte leakage method.

Saline range sites identified from photography - Weslaco, Texas (20760). Photointerpretation by microdensitometry of color infrared photography could be used to identify saline range sites quantitatively. These results showed that changes in date and scale of the photography did not significantly affect the relationship among optical density readings for saline range sites.

Range sites identified with Landsat - Weslaco, Texas (20760). Landsat digital data can be used fully to identify semiarid rangelands. Five land-use categories were identified (grassland, mixed brush rangeland, saline rangeland, cropland, and water). A highly significant linear correlation was found between photos and computer-estimated hectares for a June Landsat-2 overpass. These data indicated that useful range inventories can be made using spectral measurements from space; however, selected conditions or possibly time series data may be required to classify mixed brush rangeland.

Effects of air pollutant mixtures measures - Raleigh, North Carolina (20790). Ambient air contains a vast array of gaseous components. Three of the major phototoxic components are O₃, SO₂, and NO₂. The nine greenhouse chambers at Raleigh have permitted study of mixtures of acute and chronic pollutant using a series of 27 treatment combinations. The nature of the interaction was one of antagonism of the O₃ effects as the concentration of the NO₂ and SO₂

increased. Nitrogen dioxide played a significant role in the response of radish to SO_2 and O_3 . The results raise important implications for the siting of additional power plants in regions currently experiencing elevated O_3 levels.

SPAW tested and improved - Pullman, Washington (20800). The soil-plant-air-water (SPAW) model has been tested by several researchers in the U.S. and abroad. Work is underway to improve the evapotranspiration routines. All major meteorological factors that determine the difference of evapotranspiration between flat land and sloping land have been reviewed, evaluated, and a correction method designed that will provide a workable technique for evapotranspiration estimates on land of specific slopes and having moderate (non-mountainous) relief.

Cooperative SNOTEL research extended - Boise, Idaho (20810). A new 5-year cooperative agreement with the Soil Conservation Service (SCS) was developed. The major thrust of this research is to test improved forecasts of water supply, utilizing snowpack snow water equivalent data, and incorporating SNOTEL data into the forecast procedure. Also, development, fabrication, and testing of electronic equipment for the SCS SNOTEL system will be undertaken.

Reynolds Creek runoff predicted - Boise, Idaho (20810). The optimization forecast model developed to predict runoff at the Reynolds Creek watershed above the Tollgate weir was applied, using snow water storage values from the snow survey on March 17, 1980, of eight snow courses within the Tollgate drainage. A water supply of 18.68 cm was forecast for the irrigation season, March through July 1980, which was only 7 percent above the measured flow. The 14-year average seasonal flow at Tollgate is 19.95 cm. The snow water equivalent measured March 17, 1980, at the eight snow courses ranged from 62 to 123 percent of the 15-year average, for an overall average of 98 percent or 2 percent below the long-term average.

Probabilities estimated for annual herbage production on rangelands - Boise, Idaho (20810). Long-term herbage yield records were used to calculate the unconditional and conditional probabilities of the annual yield falling within the yield classes of below average, average, and above average. Analysis indicated only a 1-year dependency, and, therefore, a three-state Markov chain technique was used to calculate conditional yields—i.e., current yield, given last year's yield. Results indicated that the probability of a below average year following a below average year was not different from the unconditional probability of a below average year. The probability of an average year following a below average year was greater than the unconditional probability of an average year, and the probability of an above average year following a below average year was considerably less than the unconditional probability of an above average year.

Remote sensing used to detect conservation practices - Oxford, Mississippi (20810). A photo-interpretation matrix prepared by NASA personnel was reviewed at the Sedimentation Laboratory. Two research watersheds in northern Mississippi, Bear Creek and Goodwin Creek, were selected as field sites for remote sensing studies. NASA provided high altitude color infrared photographs of watersheds. "On the ground" conservation practices were located in both watersheds. These practices and others to be selected at various locations throughout the country will be used as "ground truth" in evaluating remote sensors for detecting and inventorying conservation practices and conservation needs.

Landsat data used to determine curve number (CN) - Tifton, Georgia (20810). Landsat digital data can be used to determine the Soil Conservation Service curve number model for large Coastal Plain watersheds and, perhaps, eliminate or minimize costly field surveys. Although Landsat offers considerable potential for hydrological investigations, its usefulness may be limited by the relatively poor resolution and by the technical support requirements. However, these factors do not appear to cause significant problems for Federal or State agencies concerned with large watersheds in a Coastal Plain environment.

Aircraft active microwave sensors can be used to estimate near surface soil moisture - Beltsville, Maryland (20810). Investigations have been conducted to study the relationships between active microwave measurements and soil moisture using truck-mounted systems. These studies showed the potential of the devices as moisture meters; however, they are operated under ideal, small-scale conditions and not those of an operational system. Data collected using the aircraft-mounted scatterometers over watersheds in Oklahoma were analyzed. Results showed the same patterns that were exhibited in the truck experiments. The optimal system would be a C-band scatterometer operating at an incidence angle of 15 to 20 degrees. These results support the further evaluation of active microwave sensors from high altitude platforms and improve the credibility of the truck systems in future experiments.

Soil moisture data valuable for hydrologic simulation models - Beltsville, Maryland (20810). The use of frequent measurements of surface soil moisture in hydrologic forecasting was tested in an experiment conducted on several small basins in Oklahoma. The USDA Hydrograph Laboratory model of watershed hydrology was used. Periodic soil moisture samples obtained using conventional methods represented the type of data remote sensing could provide. These data were used to evaluate the utility of periodic soil moisture measurements for parameter calibration and system updating. Analyses indicated the potential value of the data and support such evaluation on a larger scale.

Soil moisture budgeting procedure improved - Beltsville, Maryland (20810). A soil moisture budgeting procedure, more sensitive to watershed moisture status than the one in current general use, was developed and tested for application with the widely used SCS Runoff Equation. The procedure included use of a multilayered soil profile with consideration given to vegetation rooting distribution, unsaturated soil moisture redistribution, percolation, and evaporative demand. Using published data from 20 watersheds at seven locations throughout the U.S., which covered a wide range of climatic and soil regions, the procedure markedly improved runoff estimates as compared with present procedures.

Soil moisture models and remote sensing evaluation - Beltsville, Maryland (20810). Surface soil moisture variations within fields from several parts of the U.S. were examined to determine if spatial patterns existed. Variograms and trend surface analyses were used. Results indicate that spatial patterns of soil moisture are related to topography. When the topography of the area has a distinct pattern, the surface soil moisture has a similar pattern. These results suggest that remote sensing methods which integrate the response over some spatial unit may be useful where spatial patterns are at a scale too small for effective sampling.

Model developed for rapid solution of heat flow equation - Beltsville, Maryland (20810). A computer program was developed for rapid solution of the heat flow equations, which are subject to realistic meteorological and radiation fluxes at the earth's surface. This program represents the key for interpretation of satellite temperature measurements over large land areas, while permitting comparison with experimental data at field locations.

Procedure derived for determining surface temperature from satellite data - Beltsville, Maryland (20810). A procedure was developed for relating measured values of surface temperature to surface soil moisture and evaporation. Through a combination of analytic formulas and computer processing, it appears feasible that information about hydrologic variables can be derived from satellite observations of surface temperature, provided concurrent meteorological observations are available.

Precipitation models compared - Temple, Texas (20810). Three models, the one-parameter exponential distribution, the two-parameter gamma distribution, and the three-parameter mixed exponential distribution, were compared as they describe the distribution of daily rainfall amounts. The degree of fit to precipitation data was, in general, significantly greater with the mixed exponential distribution than with the exponential or gamma distribution. However, the parameters of the mixed exponential distribution were more difficult to optimize than the parameters of the other two models.

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